COMPRESSION TEST OF BUILT-UP SIGMA-SECTION COLD-FORMED STEEL COLUMNS WITH HOLES

NURUL FAIZAH BINTI MUHAMMAD RUSLI

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : NURUL FAIZAH BINTI MUHAMMAD RUSLI

ID Number : AA15033

Date : 31 MAY 2019

COMPRESSION TEST OF BUILT-UP SIGMA SECTION COLD-FORMED STEEL COLUMN WITH HOLES

NURUL FAIZAH BINTI MUHAMMAD RUSLI

Thesis submitted in Partial fulfillment of the requirements
for the award of the
B.Eng (Hons.) Civil Engineering

Faculty of Civil Engineering & Earth Resources

UNIVERSITI MALAYSIA PAHANG

MAY 2019

SPECIAL APPRECIATION

My supportive parents:

MUHAMMAD RUSLI BIN JOHARI
ZALILAH BT SUHAILI

My siblings:

MUHAMMAD SHAHNIEZAM BIN MUHAMMAD RUSLI
NURMAISARAH BINTI MUHAMMAD RUSLI
NUR AIN ASYIKIN BINTI MUHAMMAD RUSLI

And all fellow friends. Thank you.

ACKNOWLEDGEMENTS

I honor my humble respectful appreciation and gratitude towards my most graceful and love aspiring merciful Almighty Allah S.W.T for blessing me with all required knowledge, healthy and courage to successfully accomplish and render this final year project as a requirement to graduate in a Bachelor (Hons.) of Civil Engineering from Universiti Malaysia Pahang.

I dedicated my sincere gratitude and appreciations to my final year project supervisor Mr. Khalimi Johan Bin Abd Hamid for giving me an idea and continuous support for my study and research. He was extremely helpful in giving information and guidance that is beneficial for me in writing thesis and learning about testing for Cold-formed steel.

In addition, special thanks to my parents, Muhammad Rusli bin Johari and Zalilah Bt Suhaili for a support and advice that encourage me to complete and produce a high quality thesis report. Last but not least, thanks to everyone who involve in this research directly and indirectly.

ABSTRAK

Penyelidikan eksperimen telah dijalankan untuk mengkaji ujian Mampatan seksyen sigma terbina dingin yang dibentuk pada lubang Tiang keluli sejuk dan untuk menentukan beban mampatan maksimum seksyen sigma lajur keluli terbentuk sejuk. Sebanyak 8 spesimen tiang keluli dengan lubang dan tanpa lubang dan juga ketebalan 1.2 dan 2.0 mm telah diuji menggunakan mesin ujian sejagat (UTM). Aplikasi tipikal termasuk rangka untuk tingkap, pintu masuk, dinding geser, dan bangunan berbingkai berbingkai sejuk berbentuk lantai di mana lantai bawah menggunakan kancing binaan untuk membawa beban. Stud terbina dalam kajian ini terdiri daripada lapan bahagian Sigma berorientasikan back-to-back membentuk suatu keratan rentas berbentuk I. Untuk setiap spesimen, stud disambungkan ke satu sama lain dengan dua skru penggerudian diri jarak pada jarak tertentu. Seksyen trek keluli yang terbentuk sejuk bersambung yang berfungsi tegak lurus untuk setiap hujung stud yang dibina dengan skru penggerudian sendiri melalui setiap bahagian sigma. Tujuan bahagian lajur adalah untuk mengekalkan hujung kancing bersama dan mewakili lampiran akhir biasa. Hasil penyelidikan, beban mampatan maksimum ditunjukkan dan mod kegagalan kerangka keluli terbentuk sejuk dengan pelbagai kedudukan lubang

ABSTRACT

An experimental investigation was conducted to study the Compression test of built-up sigma section cold-formed steel Column holes and to determine the maximum compression load of sigma section Cold-Formed steel column. A total 8 specimen of steel column with holes and without holes and also thickness 1.2 and 2.0 mm were tested using universal testing machine (UTM). Typical applications include framing for windows, doorways, shear walls, and multi-story cold-formed steel framed buildings in which the lower floor utilizes built-up studs to carry the load. The built-up studs in this study consisted of eight Sigma sections oriented back-to-back forming an I-shaped cross-section. For each specimen, the studs were connected to each other with two self-drilling screws spaced at a set interval. A cold-formed steel track section was connected running perpendicular to each end of the built-up stud with a single self-drilling screw through each of the sigma sections. The purpose of the column section was to keep the ends of the studs together and represents a common end attachment. As a result of the investigation, the maximum compression load was shown and the mode of failure of cold-formed steel column with the various position of holes.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

mm	Milimetre
T1	Transducer 1
kN	Kilo Newton

LIST OF ABBREVIATIONS

CFS	Cold-formed Steel
BE	Built-up Sigma
HRS	Hot-rolled Steel
UTM	Universal Testing Machine
LB	Local Buckling
D	Distortional
W	Warping
LMB	Local Middle Back
LMF	Local Middle Front
WMB	Warping Middle Bac
DMB	Distortional Middle Back
LMF	Local Middle Front
WMB	Web buckling Middle Bottom
FMD	Front Middle Distortional
BMW	Back Middle Warping

CHAPTER 1

INTRODUCTION

1.1 Introduction

The building construction industry utilizes cold-formed steel members extensively to the advantages offered for the construction materials. Cold-formed steel (CFS) section has been increasingly used nowadays in different building construction, such as trusses members, floor joists and wall studs. Cold formed steel (CFS) sections are manufactured from steel sheets, strips or plates at room temperature. Cold-formed steel (CFS) sections are material that usually uses in construction for residential and commercial construction due to strong, safe, durable and effective cost with saves the construction time. In addition, CFS members are often thin-walled, therefore local plate buckling and cross section distortion and warping result in preliminary failure if not incorporated in the design.

The additional flexibility due to slip in connections further complicates the development of a suitable design method for built-up CFS members. CFS sections have many advantages compared to conventional hot-rolled steel sections, such as the ease of fabrication, low cost in transportation, handling and storage, fast erection and installation, and excellent strength to weight ratio. As the demand for light-weight steel structures continues to rise, efficient and accurate design of cold-formed steel elements is essential. One frequently used cold-formed steel member is a built-up member, formed by two or more attached steel elements back forming an I-shaped cross-section.

Open sections of CFS such as sigma sections area extensively used in light steel construction of wall, roof and floor framing members. Holes in cold formed steel structure can be found. It usually found in low and midrise construction while spaced holes are placed in the webs of cold-formed steel columns that to allow electrical, plumbing and heating services to pass through walls and ceilings. Distortional buckling is recognized as a design limit state for cold-formed steel columns with open cross-sections, separate from that of global (Moen, et al., 2009).

The most commonly used CFS sections are Z, C and sigma sections shows in figure 1.1 **Error! Reference source not found.** As a result, in recent years CFS sections have been widely used as structural members in residential and industrial buildings. The Z sections is nearly vertical when the sections are orientated in line with the pitch angle while C and sigma sections needs emerging modern shallow roof construction. The sigma shaped CFS member has recently been introduced to the US construction market as a compression member. This shape has typically been used in Europe, mainly as a roof purlin (Klingshirn, et al., 2010).

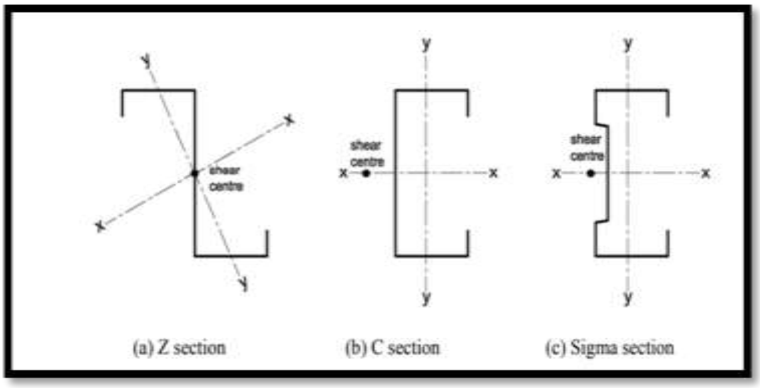

Figure 1.1 Typical CFS Z, C and sigma sections

1.2 Problem Statement

CFS sections have many advantages compared to conventional hot-rolled steel sections, such as the ease of fabrication, low cost in transportation, handling and storage, fast erection and installation, and excellent strength to weight ratio. Cold formed section usually thinner and have mode of failure and deformation as shown in Figure 1.2. Usually Cold formed section are not commonly encountered in normal structural steel design. In addition, cold formed produce structural imperfections which are quite different from traditionally hot rolled and welded members. A thin walled member under compression are possibility will occur the buckling. So that, the mode of failure such as local buckling, web buckling, Distortional buckling, flexural buckling will happen for this section.

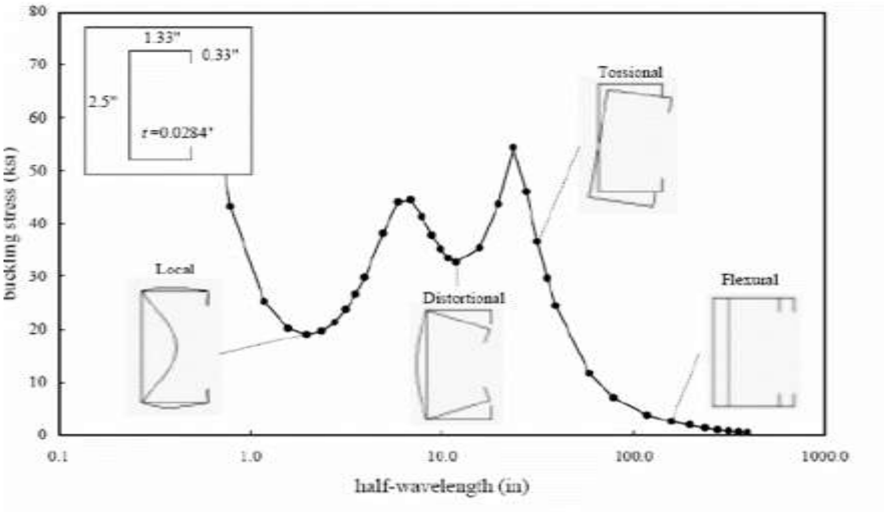

Figure 1.2 Mode of Failure

1.3 Objectives

i. To determine the maximum compression load that can be carry by open built-up steel section before failure.

ii. To identify the mode of failure of the sigma section under compression with hole and without holes.

1.4 Scope of study

To achieve these objectives, the testing in the lab will conducted to get the data analysis. The scope of this research covers the analysis of mode of failures of built-up open sections. In Figure The different distances of the opening holes with the width 103mm and thickness 1.2 mm and also 2.0mm of the specimen. The point Load has been marked to as reference of transducer was applied at the specimen. So that, the list of the Specimen needs to be tested as shown in table 1.1:

REFERENCE

Moen, (2008) ‘Experiments on cold-formed steel columns with holes’, 46, pp. 1164–1182. doi: 10.1016/j.tws.2008.01.021.

Moen, (2009) ‘Elastic buckling of cold-formed steel columns and beams with holes’, *Engineering Structures*.Elsevier Ltd, 31(12), pp. 2812–2824. doi: 10.1016/j.engstruct.2009.07.007.

Anna, 2016 (2016) ‘Study on Cold Formed Steel Sigma Sections and the Effect of Stiffeners’, (2013), pp. 16249–16255. doi: 10.15680/IJIRSET.2016.0509084

.

Bhavi, P. I. G. (2015) ‘Experimental and FEA Comparison of Cold Formed Stainless Steel and Aluminium Alloy Having Perforation of Various Combinations Subjected to Buckling Load’, 4(4), pp. 573–580.

Crisan, (2012) ‘Behaviour of cold-formed steel perforated sections in compression. Part 1 - Experimental investigations’, *Thin-Walled Structures*. Elsevier, 61, pp. 86–96. doi: 10.1016/j.tws.2012.07.016.

Darcy, G. (2005) ‘Structural behaviour of an innovative cold-formed steel building system’, (March).

Fratamico, D. C. (2018a) ‘Experimental study on the composite action in sheathed and bare built-up cold-formed steel columns’, *Thin-Walled Structures*. Elsevier Ltd, 127(February), pp. 290–305. doi: 10.1016/j.tws.2018.02.002.

Fratamico, D. C. (2018b) ‘Experiments on the global buckling and collapse of built-up cold-formed steel columns’, *Journal of Constructional Steel Research*. Elsevier Ltd, 144, pp. 65–80. doi: 10.1016/j.jcsr.2018.01.007.

Klingshirn. (2010) ‘Experimental investigation of optimized cold-formed steel compression members’, *20th International Specialty Conference on Cold-Formed Steel Structures - Recent Research and Developments in Cold-Formed Steel Design and Construction*, pp. 49–60.

Ling . (2015) ‘Numerical study of buckling behaviour of cold-formed C-channel steel purlin with perforation’, *Procedia Engineering*, 125(November 2016), pp. 1135–1141. doi: 10.1016/j.proeng.2015.11.140.

Muftah, F. *et al.* (2016) ‘Temperature development of cold formed steel column channel section under standard fire’, *AIP Conference Proceedings*, 1774(2016). doi: 10.1063/1.4965065.

Nguyen, H. T. and Kim, S. E. (2009) ‘Buckling of composite columns of lipped-channel and hat sections with web stiffener’, *Thin-Walled Structures*. Elsevier, 47(11), pp. 1149–1160. doi: 10.1016/j.tws.2009.04.011.

Reyes. (2011) ‘Evaluation of the slenderness ratio in built-up cold-formed box sections’, *Journal of Constructional Steel Research*. Elsevier Ltd, 67(6), pp. 929–935. doi: 10.1016/j.jcsr.2011.02.003.

Sadovský. (2012) ‘Buckling strength of lipped channel column with local/distortional interactions’, *Procedia Engineering*, 40, pp. 399–404. doi: 10.1016/j.proeng.2012.07.115.

Tsavdaridis. (2011) ‘Web buckling study of the behaviour and strength of perforated steel beams with different novel web opening shapes’, *Journal of Constructional Steel Research*. Elsevier Ltd, 67(10), pp. 1605–1620. doi: 10.1016/j.jcsr.2011.04.004.

Wang, C. (2016) ‘Compression tests and numerical analysis of web-stiffened channels with complex edge stiffeners’, *Journal of Constructional Steel Research*. Elsevier Ltd, 116, pp. 29–39. doi: 10.1016/j.jcsr.2015.08.013.

Yu, C. (2012) ‘Cold-formed steel flexural member with edge stiffened holes: Behavior, optimization, and design’, *Journal of Constructional Steel Research*. Elsevier Ltd, 71, pp. 210–218. doi: 10.1016/j.jcsr.2011.09.008.

Zhang. (2012) ‘Compression tests of cold-formed steel I-shaped open sections with edge and web stiffeners’, *Thin-Walled Structures*. Elsevier, 52, pp. 1–11. doi: 10.1016/j.tws.2011.11.006.

Zhao, W. (2005) ‘Behaviour and Design of Cold-formed Steel Sections with Hollow Flanges’, (September).